GERMINATION IN SOME SOUTH AFRICAN SEEDS.

By

MARGARET R. LEVYNS,

Studies in the behaviour of seeds during their resting period and during germination have been carried out to a large extent in the cold temperate regions of the Northern hemisphere. Little seems to have been done in those parts of the globe, such as the south western corner of Africa, where climatic conditions are extremely different, and the experiments about to be described will therefore help to fill a gap in our knowledge.

The coastal belt in the south western part of the Cape Province has a climate of the Mediterranean type. Most of the rain falls during the winter months, and the summer is dry and hot. Frosts are extremely rare and really low temperatures are never experienced. The dormant period for most elements in the vegetation is during the summer months, and it is therefore obvious that in those seeds where the phenomenon of after-ripening is necessary before germination can take place, the factors involved are likely to be very different from those operative in the cooler parts of the North Temperate region.

Veld fires are all too frequent in South Africa, and over the whole coastal belt the vegetation has been profoundly modified by the incidence of fire. The germination tests recorded in this paper were started in connection with experiments in veld burning. At an early stage of the investigation it was obvious that fire stimulated the seedling growth of some plants, while in other cases it had no marked effect. It therefore became necessary to study the behaviour of the seeds of typical plants. The plants chosen were,

Elytropappus rhinocerotis Less.
Anthospermum aethiopicum L.
Relhania genistaefolia L'Herit.

ELYTROPAPPUS RHINOCEROTIS.

This plant is the notorious rhenoster bush of the Cape Province. It is a grey-green shrub, from eighteen inches to four feet in height, and covers extensive areas where the soil is fairly fine grained. In parts of the country it has become a serious pest. At Stellenbosch where experiments in veld burning have been carried out (5) it has been shown that this plant has no power of establishing seedlings in untouched veld, but that after burning enormous numbers of young plants appear. If the old vegetation be cleared away but not burnt a small number of seedlings establish themselves, but these are negligible in comparison with the vast numbers that appear in response to burning. Clearly burning has some stimulating action on the seed, and it was with a view to analysing the factors concerned that these experiments were started.

The behaviour of the seed has been discussed in two previous publications (4, 6). In these it was established that the fruits are shed about the time of the first winter rains, but are immature and give a very low percentage of germinations when sown immediately. The cause of the failure to germinate appears to lie in the embryo itself and not in the fruit wall and testa. A period of after-ripening is obviously necessary and in subsequent years the capacity for germination is much greater. Up to 1929 (the date of the last publication on the subject), the figures obtained were fairly consistent, but since that date several important departures from the expected figures have been obtained in the tests. It is with the problem raised by these unexpected figures that the present paper is chiefly concerned.

Records for tests from 1925 to 1931 are given in Table 1. In all cases the seeds were sown on moistened filter paper in petri dishes. The experiments were started at the old University Buildings in Cape Town and figures obtained there are given in unshaded squares. During April 1929 the Botanical Department moved into the new University Buildings at Rondebosch, so during that year seed was stored during the Summer months in Cape Town as before but the tests were made in May at Rondebosch. These results are given in the dotted areas. All figures in areas shaded with diagonal lines were obtained at Rondebosch with seed that had been both stored and germinated there.

While in Cape Town it had been clearly shown (6) that heating the dry seed just before sowing, if not too prolonged or too intense, hastened the process of germination but had no effect on the ultimate figures. The results of the tests made in May 1929 when the temperatures recorded during the course of germination were very different from those experienced in previous years, supported the conclusion that temperature at the time of germination has no effect on the final germination figures.

The results obtained in 1930 and 1931 with seed that had been both stored and grown at Rondebosch were surprisingly poor. With the sole exception that the seed had been stored in the new University Buildings at Rondebosch instead of in Cape Town, the conditions under which the tests had been carried out were identical with those obtaining in 1929 when the results conformed with those of previous years. The obvious conclusion to be drawn from the facts is that something during the period of storage must have affected the seed. The only factor that had varied in the course of the experiments was that of temperature. In Cape Town the room in which the seeds were stored was very hot in summer and cold in winter, while the room used for this purpose at Rondebosch had a more equable temperature.

TABLE 1.

Year in which seed was collected	1st year			2nd year			3rd year			4th year			5th year			6th year			7th year		
	Max.	Min.	Av	Max.	Min.	Av	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av
1925	4	1	3	—	—	—	69	51	55	60	39	47	60	35	47	30	16	21	7	1	3
1926	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1927	4	1	2	56	33	42	65	51	59	54	43	47	40	28	35						
1928	4	1	3	60	53	55	58	37	45	54	33	41									
1929	—	—	—	47	19	27	31	20	26												
1930	—	—	—	34	26	29															

During the summer 1930-1931 some of the seed to be tested in the following May was placed out of doors, (*a*) protected from moisture in glass pots sunk in the ground, and (*b*) in muslin bags hanging up on branches of a rhenoster bush. Both lots of seed failed to give satisfactory results. The seed in the glass pots had obviously been injured by the very high temperatures experienced, while those in the muslin bags became mouldy and the moulds interfered with the results of the tests.

During the resting period of 1931-1932 a different procedure was adopted. Half the seed was stored as usual in the new University Buildings at Rondebosch and from August to May the other half was kept in the Herbarium of the South African Museum in Cape Town where the temperatures were similar to those of 1926-1929. In both places maximum and minimum thermometers were placed next the seed and records kept throughout the period. These were very different in the two places as will be seen from the figures given in Table 2.

In the first two columns the lowest daily temperatures experienced in each month are given for both places. In the next two columns the highest daily temperatures are similarly given. It will be seen that for every month the highest and lowest temperatures were obtained in Cape Town. The most striking feature of these records, however, lies in a comparison of the daily range of temperature in the two places. The minimum and maximum range in 24 hours is given for each month and the average daily range is given in the last two columns. It will be seen that while the seed stored at Rondebosch experienced a very even temperature that in Cape Town was subjected to great daily fluctuations.

TABLE 2.—A COMPARISON OF ROOM TEMPERATURES IN CENTIGRADE AT RONDEBOSCH AND CAPE TOWN DURING THE PERIOD OF SEED STORAGE.

	Temperature Records.				Records of the daily range of Temperature.					
	Minimum		Maximum		Minimum		Maximum		Average	
	Rondebosch	Cape Town	Rondebosch	Cape Town	Rondebosch	Cape Town	Rondebosch	Cape Town	Rondebosch	Cape Town
1931										
August	10·6	5·0	19·4	22·8	1·7	7·2	4·2	17·8	2·8	11·7
September	10·3	5·0	19·2	28·9	1·9	6·7	4·4	12·8	3·3	9·4
October	12·8	5·6	19·4	25·0	2·2	7·2	3·3	16·1	2·8	11·1
November	14·7	11·1	26·7	35·0	2·2	7·7	5·6	17·8	3·1	11·1
December	16·7	11·1	23·9	32·8	1·7	8·3	5·6	15·6	3·3	11·1
1932										
January	17·2	11·7	23·9	32·2	1·7	8·9	3·3	12·2	2·8	10·6
February	18·9	13·9	28·3	36·7	1·9	7·7	5·0	12·8	3·3	10·6
March	17·8	11·1	24·2	29·4	1·7	10·0	5·6	15·6	3·1	11·7
April	14·7	9·4	25·0	31·7	1·7	6·1	4·7	13·3	3·3	10·8
May (up to 13th)	14·4	9·4	27·8	31·7	1·9	6·1	3·3	12·8	2·5	10·6

On the 14th May germination tests were started in the usual manner, i.e. seeds were counted into lots of 100 each and sown on damp filter paper in petri dishes. The seed which had been subjected to the more extreme temperatures in Cape Town gave results comparable with those given by seeds which had received similar treatment in the years 1928 and 1929 (see Table 1, 2nd column). In corresponding manner, the seed which had been subjected to the more equable temperatures of Rondebosch gave results agreeing with those obtained in 1930 and 1931. There can therefore be little doubt that some temperature factor is operative in facilitating the process of after-ripening. At present it is impossible to say what the precise nature of the factor is. The fact that a veld fire promotes germination suggests that high temperatures rather than low ones are of importance. It may well be that within the limits of ordinary room temperatures great daily fluctuations are of more importance than the absolute maximum experienced, but further experiments are needed.

TABLE 3.—GERMINATION TESTS. 100 SEEDS SOWN IN EACH PETRI DISH.

Date on which test was started.	Stored in Rondebosch.	Stored in Cape Town.
14th May	51	57
	33	54
	25	67
	48	43
	Total 157 Average 39·25%	Total 221 Average 55·25%
27th May	62	72
	68	76
	63	72
	69	83
	Total 262 Average 65·5%	Total 303 Average 75·75%
14th June	77	90
	76	82
	75	87
	74	82
	Total 302 Average 75·5%	Total 341 Average 85·25%

In previous years only one series of tests was made and these were always carried out at the same time of year, starting in the middle of May, the time at which the rhenoster seed ripens on the plant. In 1932 however, it was considered desirable to get larger numbers and further tests were made, a second lot being started on May 27th and a third on June 14th. Since the middle of May all seeds had been kept at Rondebosch. The figures obtained in these later tests are given in Table 3, and although the same difference may be observed between the seed stored in Cape Town and that kept in Rondebosch, the difference is by no means as sharp. In both tests the number of germinations in each petri dish is far higher than in the earlier test. In fact these numbers are far higher than any obtained before. Reference to Table 1, which sums up the results of tests made with several thousands of seeds, reveals the fact that 69% is the highest figure previously recorded. What meaning is to be attached to these results is obscure. The temperature records which were kept while the tests were in progress show nothing to explain the results.

The results just recorded are obviously in need of explanation but they must not be allowed to obscure the fact now established that the dry seed of the rhenoster bush is susceptible to the influence of temperature during its resting period.

Up to the present our knowledge of dormancy in seeds has been derived largely from experimental studies on plants inhabiting cold temperate climates. Crocker (1) and many other writers have pointed out that seeds which fail to germinate when placed under suitable conditions may fail to do so for one or more of several reasons. The embryo may be immature and in these cases a series of changes termed after-ripening must take place before germination is possible. In other cases the cause of failure to germinate lies in the seed coat which may enforce dormancy by preventing water absorption, by inhibiting gas exchange or by preventing expansion of the embryo.

In the rhenoster seed the cause of dormancy almost certainly lies in the embryo and not in the pericarp. Fresh seed when sown absorbs water just as rapidly as that which has matured. Removal of the pericarp in fresh fruits is a difficult operation as in addition to their minute size the embryos are extremely soft and lack the firmness of texture which characterises them when mature. Attempts to remove the pericarp at this stage have usually resulted in injury to the embryo, and moulds have destroyed the few uninjured embryos that were obtained. Thus it is impossible to say if the pericarp plays any part in the phenomenon of dormancy in the rhenoster seed. However, the change from the soft, somewhat amorphous embryo of the first year seed to the firm, sharply differentiated one of older seed, renders it probable that the cause of dormancy lies in the embryo itself.

Several workers have made a study of seeds showing dormancy due to the necessity for after-ripening processes in embryo, endosperm or both. Davis and Rose (2) have shown that in the seed of the hawthorn (*Crataegus mollis*) the process of after-ripening is favoured by low temperatures in the neighbourhood of 5° C. Similar results have been obtained by Rose (8) for *Tilia americana* and Pack (7) for several species of *Juniperus*. In all these cases the process of after-ripening takes place while the seeds are fully supplied with water. Few cases have been recorded where changes of this nature have occurred with the seed in an air-dry condition. Gassner (3) has reported such an instance in the case of the seeds of certain South American grasses where dry storage at a temperature in the neighbourhood of 55° C. caused a marked increase in germinating capacity. The interest of the present case lies in the fact that it has been possible to demonstrate a change in germinating capacity in seeds stored at different room temperatures. At Rondebosch these temperatures ranged from 10·3° C. to 28·3° C., while for the same period in Cape Town the figures ranged from 5° C. to 36·7° C.

A feature of the rhenoster seed which is probably of considerable benefit to it under natural conditions is the protracted period during which seeds will continue to germinate. Seeds start germinating a little over a week after sowing and the majority germinate within fifteen days, but odd seedlings continue to appear for several weeks. It has been shown in an earlier publication (4) that young seedlings are most susceptible to drought even of a temporary nature, and the protracted period of germination will ensure the survival of at any rate some of any given sowing.

ANTHOSPERMUM AETHIOPICUM.

This bush is frequently associated with the rhenoster bush in areas where a moderately high rainfall is experienced, but apart from this association it has little in common with the rhenoster bush. Many farmers consider it a valuable plant indicator. Soils on which it grows abundantly are regarded as being suitable for the cultivation of deciduous fruits. While seedlings of the rhenoster bush are stimulated by a veld fire, the seedlings of this plant occur in equal numbers on burnt and unburnt areas.

Fruit is produced in great abundance during the early summer months, and is frequently retained on the parent plant until the winter. Each mericarp is between 2 and 3 mm. in length, is somewhat bulky and possesses no special facilities for bringing about distribution. In this respect it is in marked contrast with the rhenoster bush, the fruits of which are admirably adapted for wind dispersal.

Most of the fruits contain viable seed and the germinating capacity is high. The method adopted here was the same as that employed in the case of the rhenoster seed, viz. three or more petri dishes with 100 seeds on moistened filter paper in each, were established each year. The seed used in these experiments was collected at Stellenbosch in December 1926 and sown for the first time in May 1927. In the four subsequent years similar sowings were made in the same month. For the first four years an average germination of between 80% and 90%

was maintained, but in the fifth year it dropped to 69%, showing that a process of deterioration had begun.

The accompanying graph illustrates the changes in germinating capacity of the seed in relation to age. In order not to complicate presentation, curves for the years 1927, 1929 and 1931 have been given, the intermediate years being omitted. These curves show that in fresh seed germination starts early, rapidly attains a maximum and then falls off sharply, ending on the 12th day after sowing. Two years later the maximum period occurs slightly later, and seeds continue to germinate until the 18th day. In seeds four years old the maximum period is much later and is less well defined. The whole germinating period is much more protracted, continuing till the 39th day.

RELHANIA GENISTAEFOLIA.

This plant is frequently found in association with the rhenoster bush, and a special feature is its dimorphic fruits. Those of the disc florets are smooth, circular in transverse section and crowned with a pappus of small, acute scales. Those of the ray florets are covered with stiffish white hairs, and are triangular in transverse section. The pappus is the same as in the disc florets. Neither fruit is adapted for wind distribution but animals may well assist in the case of the ray fruits. Fruits are formed during November and December and are shed at once.

Tests carried out in petri dishes showed that the fresh seed had an average of 72% of germination for fruits of the ray florets and 17% for fruits of the disc florets. Some of the seed was kept for a year and then tested once more. The figures were then slightly higher, being 78% for the ray fruits and 21% for the disc fruits. The general type of germination is similar to that of *Anthospermum aethiopicum*. Germination starts about the fifth day and reaches its maximum at an early stage. The duration of the period is from 14 to 20 days.

The writer wishes to take this opportunity of thanking Miss S. Garabedian for her co-operation. During the period from August to May, while some of the seeds were being stored in the Herbarium of the South African Museum, Miss Garabedian kept a record of the maximum and minimum temperatures for each day. These records form an integral part of this paper.

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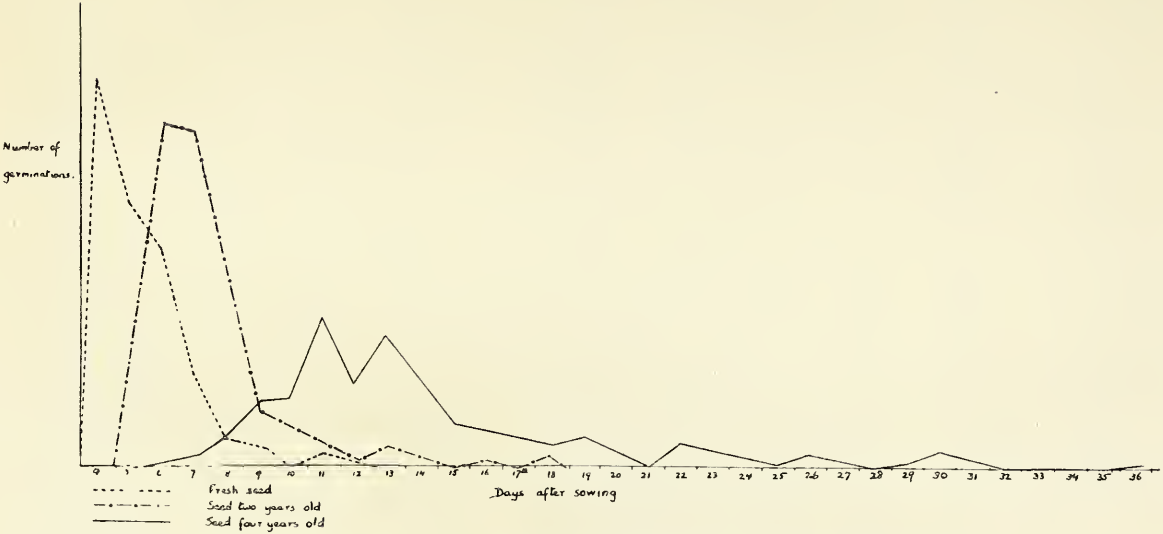

Anthospermum aethiopicum. Changes in germinating capacity of seed in relation to age.

SUMMARY.

1. The germinating capacity of the seeds of the three following plants have been studied; *Elytropappus rhinocerotis* (the rhenoster bush), *Anthospermum aethiopicum* and *Relhania genistaefolia.*

2. The seed of the rhenoster bush is much stimulated by veld fires under natural conditions.

3. Fresh seed of this plant has a very low germinating capacity, but if stored dry will give a much higher percentage of germinations the next year and this enhanced capacity for germination is maintained for several years.

4. Reasons are given for regarding this increase in germinating capacity as being due to after-ripening processes in the embryo.

5. Temperature operating while the seeds are in an air-dry condition, is shown to play an important part in these after-ripening processes.

6. The stimulus of fire has no effect on the seeds of *Anthospermum aethiopicum*. No after-ripening is necessary in these seeds, germination normally taking place a few months after the fruits are produced. The germinating capacity is high. In seed that is not more than four years old germination takes place rapidly. After the fourth year of storage signs of deterioration are apparent.

7. *Relhania genistaefolia* has dimorphic fruits. Those produced by the ray florets have a much higher capacity for germination than those of the disc florets. No period of after-ripening is necessary.

LITERATURE CITED.

1. CROCKER, W.: "Mechanics of dormancy in seeds." Am. Journ. Bot. III, pp. 99—120. (1916.)
2. DAVIS, W. C. and ROSE, R. C.: "The effects of external conditions upon the after-ripening of the seeds of *Crataegus mollis*." Bot. Gaz. LIV, pp. 49—62. (1912.)
3. GASSNER, G.: "Uber Keimungsbedingungen einiger Südamerikanischer Gramineensamen," II. Ber. Deutsch. Bot. Gesell. XXVIII, pp. 504—512. (1910.)
4. LEVYNS, MARGARET R.: "A preliminary note on the rhenoster bush and the germination of its seed." Trans. Roy. Soc. S. Af. Vol. XIV, pp. 383—388.
5. LEVYNS, MARGARET R.: "Veld-burning experiments at Ida's Valley, Stellenbosch." Trans. Roy. Soc. S. Af., Vol. XVI, pp. 61—92. (1929.)
6. LEVYNS, MARGARET R.: "The problem of the rhenoster bush." S. Af. Journ. Sci., Vol. XXVI, pp. 166—169. (1929.)
7. PACK, D. A.: "After-ripening and germination in Juniperus seeds." Bot. Gaz. LXXI, pp. 32—60. (1921).
8. ROSE, R. C.: "After-ripening and germination of seeds of *Tilia*, *Sambucus* and *Rubus*." Bot. Gaz., LXVII, pp. 281—308. (1919.)